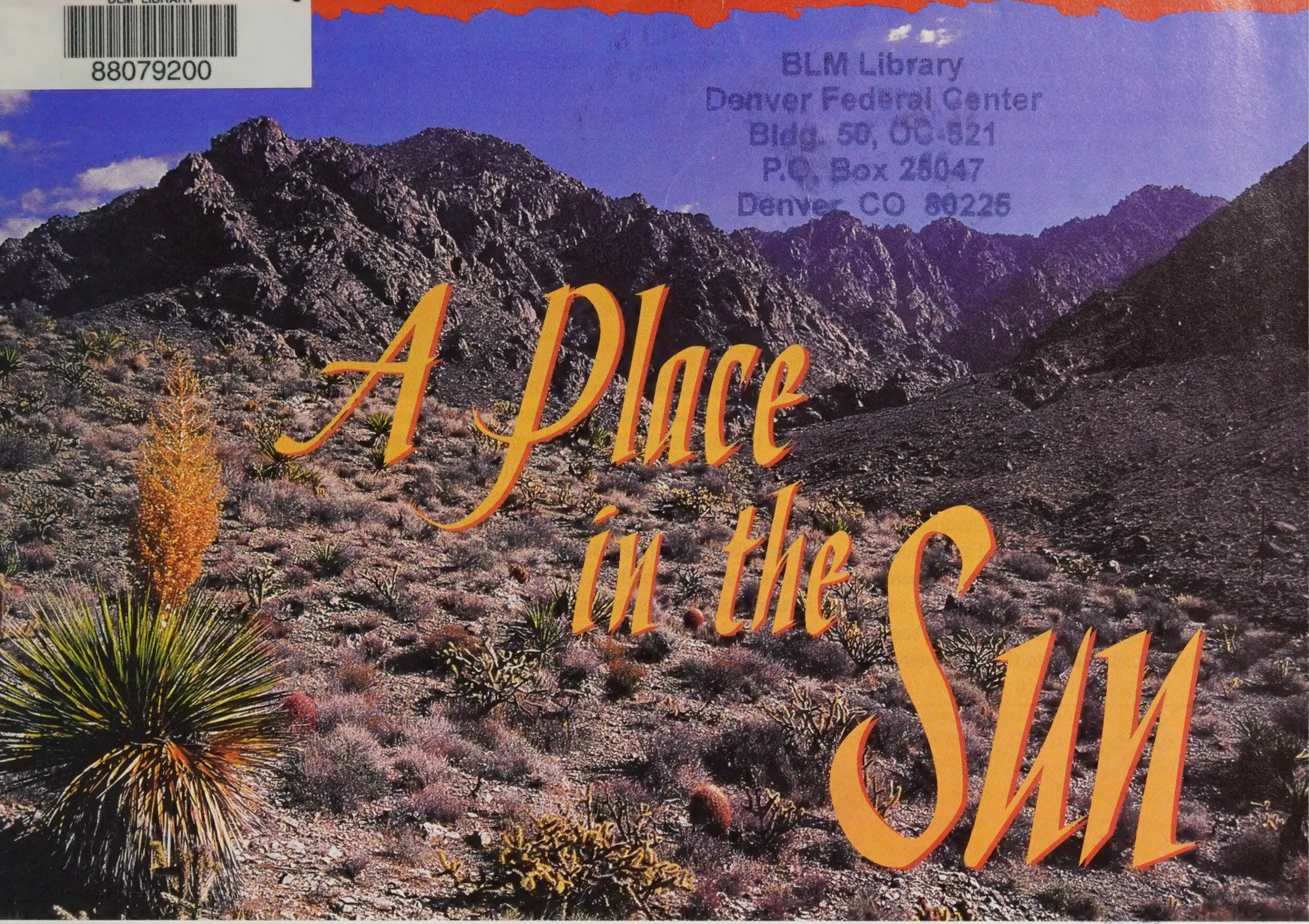
BY BIBI BOOTH, RICHARD BROOK, ELIZABETH RIEBEN, AND ELIZABETH WOOSTER

BLM LIBRARY
88079200

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

A Place in the Sun



DORAN SANCHEZ, BLM

> To the north I looked out over the Mojave Desert… from this point a wilderness of mountains, arid, aerial, almost phantasmal. "Come," they seemed to say, "we are waiting for you, have waited since eternity began."
>
> J. SMEATON CHASE
> *CALIFORNIA DESERT TRAILS*, 1919

A World Apart

After hundreds of years of exploration, the Mojave Desert remains an emblem of tantalizing emptiness, the quintessential American desert. Throughout its existence, the Mojave has been a stark and inhospitable habitat, suitable for only the most stalwart plant and animal species and the most resourceful of human beings. As one Mojave author put it, "To define the scenery as 'breathtaking' doesn't explain exactly how it takes your breath away: by sitting on your chest and pressing on your head."

The most vulnerable and symbolic of America's deserts, the Mojave has long been viewed as a parched, endless wasteland—perfect for the dumping of society's discards. In fact, during World War II, General Patton's soldiers, training in the Mojave for North African desert missions, referred to the Mojave as "the place that God forgot." Today a new attitude celebrates the Mojave as a rich, complex world of open space and a haven for humans seeking refuge from civilization.

The Mojave Desert is a fragile, 125,000 km^2, Ohio-sized landscape spread over southern Nevada, western Arizona, southwestern Utah, and one-fourth of California. Ecologically, the Mojave was once considered a transition between the Colorado Desert, the Great Basin, and the Sonoran Desert. It is now recognized as a separate desert, largely because of the many distinctive plant species that live there. This unique region stretches from the outskirts of Los Angeles to beyond Las Vegas, encompassing such classic American features as Route 66 and Death Valley.

The paradoxical Mojave is at once delicate and resilient, exotic yet within a day's drive for 40 million people, desolate yet home to thousands of remarkable species.

Shaping the "Classic American Desert"

Despite its archetypal status, the Mojave does not really fit the classic image of a desert. For example, it contains sand dunes only in limited areas, and is characterized by parched mountains that rise abruptly from alternating plains, or basins. The area of most dramatic relief is around Death Valley, California, where the elevation drops from 3,400 m above sea level at Telescope Peak to 88 m below sea level at Badwater—a surface distance of only 23 km.

The Mojave's mountains are in fact burying themselves in their own debris as storm-driven rocks and boulders pour from canyons, spreading out to build gigantic alluvial slopes. Where several deposits join, they form *bajadas*, long, sedimentary slopes sprinkled with cacti and creosote bush.

Bajadas are capped with *desert pavement*, composed of gravel and small rocks, overlaid with delicate *desert varnish*—thin clay and other particles cemented to rock surfaces by manganese and iron that have been oxidized by bacteria over thousands of years. The large expanses of the Mojave's bajadas make them the dominant geomorphologic feature of the Mojave Desert ecosystem.

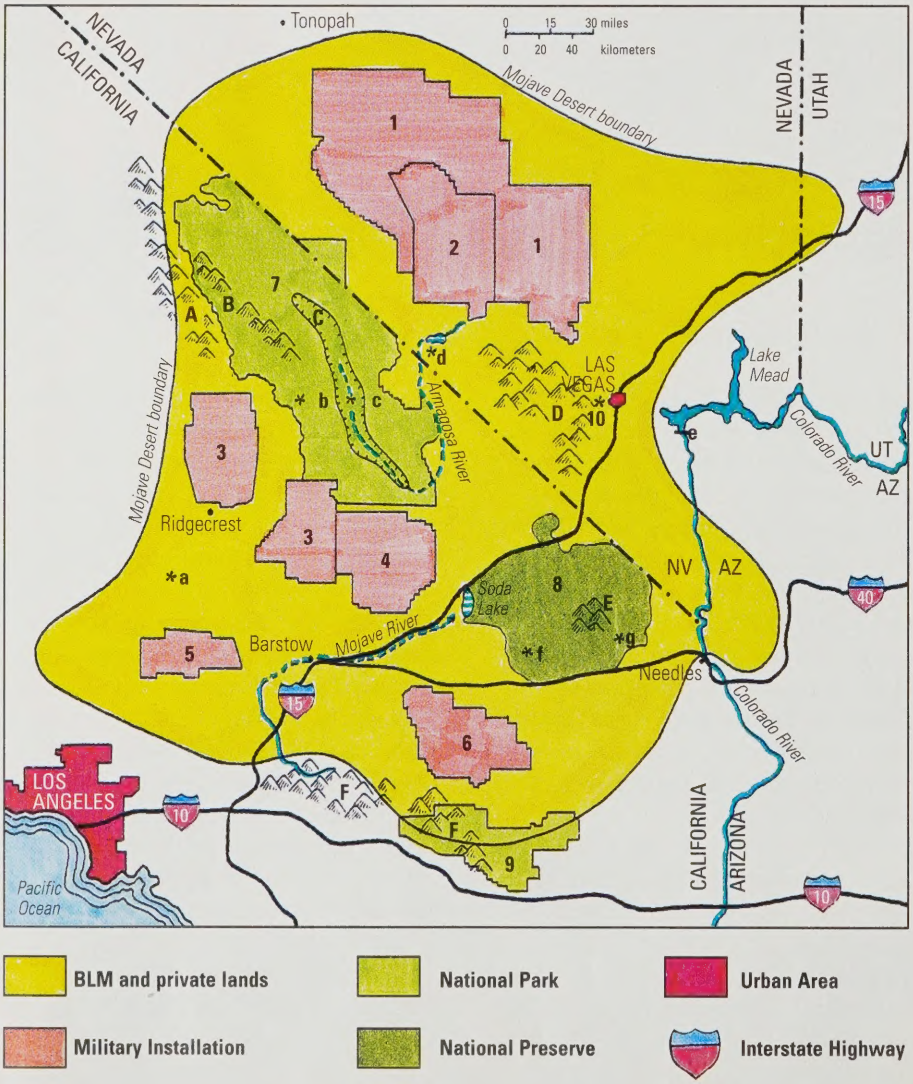
Since basins have no outlets, when rainfall collects and evaporates, it leaves behind flat alkaline deposits on which almost nothing will grow. The white surfaces of these *playas*, or dry lakes, are startling against the duller, brown background. Playas, such as Soda Lake at the end of the Mojave River in California, are among the flattest landforms in the world. Dry riverbeds, or *arroyos*, are also present in the Mojave, as are volcanic remnants.

DORAN SANCHEZ, BLM

The sands of Kelso Dunes, within the Mojave National Preserve, are of a rare type known as "booming" sands because of their tendency to hum or boom when in motion. About 200 m high, these dunes are some of the tallest in North America.

The Mojave Desert is a subsection of the Basin and Range Physiographic Province, which is characterized by long, north-south-trending mountain ranges separated by broad valleys. Igneous, metamorphic, and sedimentary rocks of the Mojave Desert reveal prehistoric landscapes as old as 2.7 billion years—over half the age of the Earth.

During the Paleozoic era the Mojave Desert was covered by shallow seas, as evidenced by fossil marine creatures in limestone and dolomite. These fluctuating seas deposited thousands of meters of sediment that can be seen in banded mountains throughout the Mojave. Limestone has played an important role in the history of the Mojave as a host



Map Key

1. Nellis Air Force Range
2. Nevada Test Site
3. China Lake U.S. Naval Air Weapons Testing Area
4. Fort Irwin National Training Center
5. Edwards Air Force Base
6. Marine Corps Air Ground Combat Center
7. Death Valley National Park
8. Mojave National Preserve
9. Joshua Tree National Park
10. Red Rock Canyon National Conservation Area

A. Inyo Mountains
B. Panamint Mountains
C. Death Valley
D. Spring Mountains
E. Woods Mountains
F. San Bernardino Mountains

a. Desert Tortoise Research Natural Area
b. Telescope Peak
c. Badwater
d. Ash Meadows National Wildlife Preserve
e. Hoover Dam
f. Kelso Dunes
g. Lanfair Valley

#139115947 ID:88079200 GE 77 .B659 2001

rock for metallic mineral veins, which were produced when magma intruded.

During the Mesozoic era the Mojave region was uplifted. Salt-laden water bodies evaporated, leaving behind puffy crusts of evaporite minerals, such as halite and gypsum. Rivers and ephemeral streams carried large amounts of eroded materials into the lowlands.

DORAN SANCHEZ, BLM

The towering, multihued spires of Red Rock Canyon evidence the strong carving power of water. The area's rugged cliffs have been used as a scenic backdrop for countless motion pictures and television programs.

The Mojave's climate became even more arid and windy than it is today, causing the formation of belts of sand dunes and creating the cross-bedding patterns that are visible in the colorful sandstone of Nevada's Red Rock Canyon and elsewhere.

At the beginning of the Cenozoic era tectonic activity resumed. Movement along faults deformed the Mojave's layers of sediment and underlying metamorphic rock. Shifts along thrust faults forced older layers on top of younger ones, as can be seen at Red Rock Canyon National Conservation Area.

Faulting was accompanied by an increase in volcanic activity. At present-day Death Valley, these processes pushed up mountains and caused the valley floor to drop, forming a below-sea-level trough. Hot springs near Nevada's Lake Mead and cinder cones and lava flows in the eastern Mojave are reminders of this active period. About 17.8 million years ago, a powerful volcanic eruption in the Woods Mountains dispersed a low cloud of ash and rock fragments across the countryside, burying shallow lakes and stands of trees. The fossils of ancient life forms are preserved in sediments below this ash layer.

The Mojave is a geological "accommodation zone" between the surrounding Pacific and North American plates, which causes the region to experience relatively strong earthquake activity along numerous faults. For example, a 7.6 magnitude earthquake in the western Mojave shook a wide area in June 1992—the largest quake to strike California in 40 years. In October 1999, a 7.1 magnitude earthquake jolted Barstow, California, and surrounding areas. Twenty-five aftershocks of magnitude 4.0 or greater occurred within 36 hours of the main shock.

Life at the Extremes

The Mojave Desert, the driest and smallest of the North American deserts, occupies only 7 percent of the total arid lands of North America, yet offers a wide diversity of habitats, from salt pans to mesa tops, high sand dunes to alkaline springs. It is home to over 2,500 species of plants and animals, more than 100 of which are considered to be in some degree of peril.

The Mojave receives an average of less than 15 cm of precipitation per year, distributed unevenly. The California portion of the desert, for example, often receives as little as 3 cm of rain. In fact, the Mojave is considered a *rain shadow* desert because the mountains surrounding it block precipitation. The former community of Bagdad, California, once went an incredible 767 days without a drop of rain. Summers are long and hot in the Mojave; in fact, the highest temperature ever recorded in North America was 57°C in 1913 at Death Valley.

The Mojave Desert is dominated by low, widely spaced shrubs, including the creosote bush (*Larrea tridentata*) and Mojave sage (*Salvia mohavensis*). The Mojave flora includes few trees other than the signature Joshua tree (*Yucca brevifolia*), but features a number of cacti, several parasitic plants, and a vast variety of wildflowers. About 25 percent of the plant species in the Mojave are *endemics*—found nowhere else in the world. The spiny-armed Joshua tree lives only within the Mojave Desert; in fact, the boundaries of the species' range define the areal limits of the ecosystem. And some remnant environments *within* the Mojave host plant species that are found nowhere else within even this ecosystem.

The Mojave's diversity of vegetation results from its extensive variety of rock types, wide range of elevations, and the existence of microclimates. Some of the higher mountain ranges, such as the Spring Mountains, even host coniferous forests.

The fauna of the Mojave Desert is composed of both wide-ranging species, such as the desert bighorn sheep (*Ovis canadensis*) and jackrabbit, and highly specialized species that live only in small relic habitats, including the Inyo Mountain's slender salamander (*Batrachoseps campi)* and several species of pupfish (*Cyprinodon* sp.).

Because of the harsh nature of the Mojave Desert ecosystem and the rarity of free water, riparian systems provide oases of species diversity not found elsewhere in the region. Important riparian systems within the Mojave include the Colorado, Mojave, and Amargosa Rivers. Desert springs also offer some of the Mojave's most unique riparian environments. Virtually all Mojave riparian systems are extremely deteriorated because of the introduction of exotic flora and fauna and the diversion of water resources by humans.

DORAN SANCHEZ, BLM

A host of insects, birds, and other animals are partially or entirely dependent on the Joshua tree for food or shelter. In the case of the yucca moth, Pronuba yuccasella, *the relationship is symbiotic: only this small white moth has adapted to pollinate the Joshua tree, which could not survive as a species without it.*

Management Challenges

The Mojave Desert encompasses large tracts of publicly owned lands. The Bureau of Land Management (BLM), the National Park Service, and the Department of Defense manage most of these lands. But because ecosystems do not recognize such boundaries, federal land managers work in cooperation with one another, local governments, and private landowners.

Rapid urban expansion—coupled with scarce water resources—creates special management challenges for the entire region. Increased human use of the desert is the direct cause of the majority of resource issues. Livestock grazing, utility corridors, military training, and recreational activities all impact fragile native plants and animals.

In addition, pressure is mounting as cities and counties grow up to adjacent public land boundaries with no room to expand. In some cases, federal lands near cities are being sold or exchanged for more environmentally sensitive lands further from urban areas. For example, Congress is considering legislation that would sell public lands to Clark County, Nevada, for construction of a new airport to serve Las Vegas. The money from this sale could be used to buy environmentally important land elsewhere.

While some see the desert as a barren landscape suitable for garbage dumping, many citizens understand the beauty and fragility of the landscape and seek to restore it. A recent volunteer cleanup of public lands near Barstow, for example, attracted more than 500 people from nearby communities, who collected 5.5 metric tons of trash, including discarded cars and washing machines.

The Mojave Desert attracts millions of tourists each year to such sites as Death Valley, Lake Mead, Joshua Tree National Park, the Mojave National Preserve, and the millions of acres of public lands containing canyons, sand dunes, and dry lakes managed by the BLM. Therefore, managers not only must protect the fragile desert environment, but they also must plan to accommodate an increasing variety of uses and demands for desert lands.

DORAN SANCHEZ, BLM

California's Afton Canyon, one of few places where the Mojave River flows aboveground, is a prime location for camping, bird watching, and wildlife viewing.

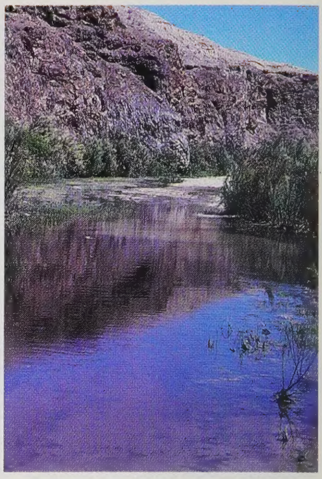
Water

Groundwater and the Mojave and Colorado Rivers are the primary water sources for the Mojave Desert's plants and animals, and for the booming populations of desert cities. Las Vegas is the nation's fastest growing city; its population is expected to double in the next 40 years. In southern California, fast-growing desert communities in Victor and Antelope Valleys will nearly double in size over the next 25 years. Providing water to sustain metropolitan growth in desert areas is a constant challenge, and often has extreme consequences. For example, so much water is drawn out of the Colorado River that it often runs dry before it reaches the Pacific Ocean.

Las Vegas—"the meadows" in Spanish—was once watered by underground springs, creating a natural oasis. Today this groundwater is pumped faster than it is replenished, so much of the city's water is pumped from the Colorado River at nearby Lake Mead, one of several reservoirs for Mojave communities. (Reservoirs hold vast amounts of water, but their huge surface areas result in considerable evaporation in desert environments.)

Because local water demand is fast approaching capacity, large-scale engineering projects to draw more water from Lake Mead are underway. Complex water laws control the amount of water that can be taken by each state. With a finite amount of water available locally, new water sources will eventually be needed if growth is to be sustained. Proposals to pipe water from distant aquifers will cost billions of dollars.

Critics fear that the ecological costs of such plans could also be great. Groundwater pumping to serve urban and agricultural areas lowers the water table, which can have devastating impacts on desert habitats such as mesquite woodlands and fragile riparian complexes. Some interested parties are calling for more water conservation and restrictions on urban growth to ensure a healthy water supply for communities as well as for the Mojave's plants and animals.


DORAN SANCHEZ, BLM

Afton Canyon is designated as an Area of Critical Environmental Concern to protect plant and wildlife habitat and to preserve the scenic values of the canyon's riparian area.

Off-Highway Vehicles

One of the more popular—and controversial—recreational uses of the desert is riding motorcycles, all-terrain vehicles, dune buggies, and four-wheel-drive cars and trucks. Such off-highway vehicles (OHVs) can seriously damage fragile desert ecosystems. Compacted soils severely inhibit the growth of plant roots. They also keep water from seeping into the ground, increasing water runoff and altering the water-holding capacity of the soil. This is particularly significant because disturbed desert soils can take thousands of years to be restored given

DORAN SANCHEZ, BLM

Off-highway vehicle use can damage fragile desert soils, leaving scars that may persist for many years.

DORAN SANCHEZ, BLM

The Stoddard Valley Off-Highway Vehicle Area near Barstow, California, offers diverse landscapes for off-highway vehicle recreation. The area is characterized by steep, rocky mountains; rolling hills; open valleys; and winding sandy washes.

The Dry L

Management Challenges

The Mojave Desert encompasses large tracts of publicly owned lands. The Bureau of Land Management (BLM), the National Park Service, and the Department of Defense manage most of these lands. But because ecosystems do not recognize such boundaries, federal land managers work in cooperation with one another, local governments, and private landowners.

Rapid urban expansion—coupled with scarce water resources—creates special management challenges for the entire region. Increased human use of the desert is the direct cause of the majority of resource issues. Livestock grazing, utility corridors, military training, and recreational activities all impact fragile native plants and animals.

In addition, pressure is mounting as cities and counties grow up to adjacent public land boundaries with no room to expand. In some cases, federal lands near cities are being sold or exchanged for more environmentally sensitive lands further from urban areas. For example, Congress is considering legislation that would sell public lands to Clark County, Nevada, for construction of a new airport to serve Las Vegas. The money from this sale could be used to buy environmentally important land elsewhere.

While some see the desert as a barren landscape suitable for garbage dumping, many citizens understand the beauty and fragility of the landscape and seek to restore it. A recent volunteer cleanup of public lands near Barstow, for example, attracted more than 500 people from nearby communities, who collected 5.5 metric tons of trash, including discarded cars and washing machines.

The Mojave Desert attracts millions of tourists each year to such sites as Death Valley, Lake Mead, Joshua Tree National Park, the Mojave National Preserve, and the millions of acres of public lands containing canyons, sand dunes, and dry lakes managed by the BLM. Therefore, managers not only must protect the fragile desert environment, but they also must plan to accommodate an increasing variety of uses and demands for desert lands.

DORAN SANCHEZ, BLM

California's Afton Canyon, one of few places where the Mojave River flows aboveground, is a prime location for camping, bird watching, and wildlife viewing.

Water

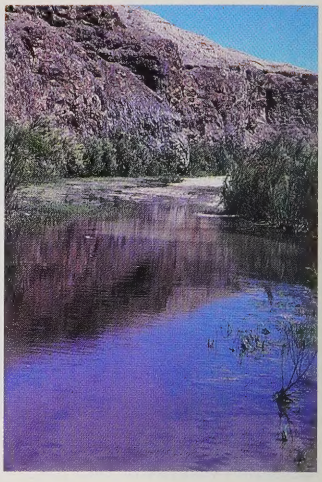
Groundwater and the Mojave and Colorado Rivers are the primary water sources for the Mojave Desert's plants and animals, and for the booming populations of desert cities. Las Vegas is the nation's fastest growing city; its population is expected to double in the next 40 years. In southern California, fast-growing desert communities in Victor and Antelope Valleys will nearly double in size over the next 25 years. Providing water to sustain metropolitan growth in desert areas is a constant challenge, and often has extreme consequences. For example, so much water is drawn out of the Colorado River that it often runs dry before it reaches the Pacific Ocean.

Las Vegas—"the meadows" in Spanish—was once watered by underground springs, creating a natural oasis. Today this groundwater is pumped faster than it is replenished, so much of the city's water is pumped from the Colorado River at nearby Lake Mead, one of several reservoirs for Mojave communities. (Reservoirs hold vast amounts of water, but their huge surface areas result in considerable evaporation in desert environments.)

Because local water demand is fast approaching capacity, large-scale engineering projects to draw more water from Lake Mead are underway. Complex water laws control the amount of water that can be taken by each state. With a finite amount of water available locally, new water sources will eventually be needed if growth is to be sustained. Proposals to pipe water from distant aquifers will cost billions of dollars.

Critics fear that the ecological costs of such plans could also be great. Groundwater pumping to serve urban and agricultural areas lowers the water table, which can have devastating impacts on desert habitats such as mesquite woodlands and fragile riparian complexes. Some interested parties are calling for more water conservation and restrictions on urban growth to ensure a healthy water supply for communities as well as for the Mojave's plants and animals.

Afton Canyon is designated as an Area of Critical Environmental Concern to protect plant and wildlife habitat and to preserve the scenic values of the canyon's riparian area.


DORAN SANCHEZ, BLM

Off-Highway Vehicles

One of the more popular—and controversial—recreational uses of the desert is riding motorcycles, all-terrain vehicles, dune buggies, and four-wheel-drive cars and trucks. Such off-highway vehicles (OHVs) can seriously damage fragile desert ecosystems. Compacted soils severely inhibit the growth of plant roots. They also keep water from seeping into the ground, increasing water runoff and altering the water-holding capacity of the soil. This is particularly significant because disturbed desert soils can take thousands of years to be restored given

DORAN SANCHEZ, BLM

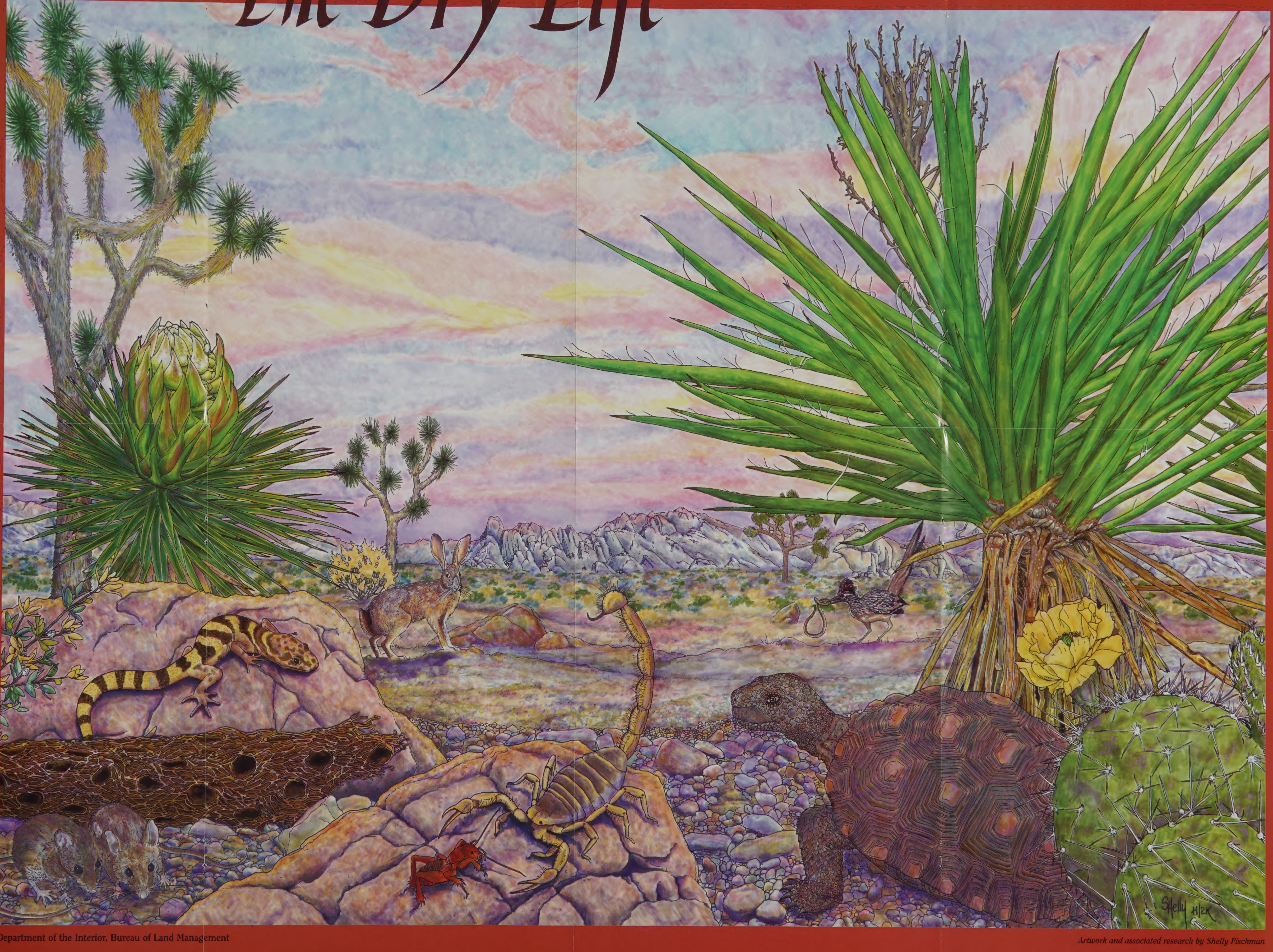
Off-highway vehicle use can damage fragile desert soils, leaving scars that may persist for many years.

DORAN SANCHEZ, BLM

The Stoddard Valley Off-Highway Vehicle Area near Barstow, California, offers diverse landscapes for off-highway vehicle recreation. The area is characterized by steep, rocky mountains; rolling hills; open valleys; and winding sandy washes.

Mojave Desert Ecosystem

The Dry Life



Department of the Interior, Bureau of Land Management

Artwork and associated research by Shelly Fischman

ert Ecosystem

BLM Library
Denver Federal Center
Bldg. 50, OC-521
P.O. Box 25047
Denver, CO 80225

the desert's limited supply of biodegradable materials (or *biomass*), intense solar exposure, and low moisture.

Vehicles can also cause direct damage by running over and destroying plants and even animals such as lizards and tortoises, or crushing the underground burrows where tortoises often spend much of the day. As a result, OHV use is managed by federal agencies to keep vehicles away from the most fragile areas, while allowing OHV activities on more durable surfaces, such as barren sand dunes or clay flats. In most cases OHV use is confined to designated roads and trails; some areas are fenced to keep vehicles out of sensitive habitat. Other areas, such as the Desert Tortoise Research Natural Area near Ridgecrest, California, and designated wilderness areas within the Mojave, are closed to OHV use altogether. In many areas of the Mojave the BLM has implemented OHV policies that require active management of sensitive areas.

Balanced management helps prevent OHVs from stirring up and loosening thin desert topsoil layers—which accelerates erosion—or destroying *microbiotic crusts*, thin soil surface layers bound together by living microorganisms, including lichens and algae. At the same time, management of OHV access avoids soil compaction and the creation of hardened "roadways."

Extensive military exercises that entail the movement of heavy equipment also can have serious impacts on desert soils similar to, but much more intensive than, those caused by OHVs. The U.S. Army, Air Force, Marine Corps, and Navy all operate major training or testing facilities in the Mojave Desert. The Department of Defense is working with the Department of the Interior to reduce the impact of its activities.

Utility Corridors

Because the Mojave Desert is sandwiched between high-tech, urban areas, there is an increasing need to connect these areas with new fiber-optic telecommunications lines and other utility services. Often these utility rights-of-way bisect wildlife habitat, causing weeds to spread and reducing species diversity. Land managers are working with utility companies to reduce these impacts by establishing right-of-way corridors along already established routes and by limiting new routes.

U.S. GEOLOGICAL SURVEY

Constructed in the 1960s, the Los Angeles Aqueduct carries water from Owens Valley, Nevada, to Los Angeles, California. The land's recovery from the aqueduct's burial is still incomplete as evidenced by the nearly barren surface strips extending from either end of this exposed portion of the pipeline where it crosses a canyon.

Sensitive Fish Species

With water in diminishing supply, desert fish species face great peril. In fact, more than half of the native desert fish species in the Mojave are either federally listed as threatened or endangered or are species of concern. An estimated eight percent are already extinct. Native desert fish often are specifically adapted to the heat and elevated salinity of the water, particularly those species that evolved in small, isolated springs.

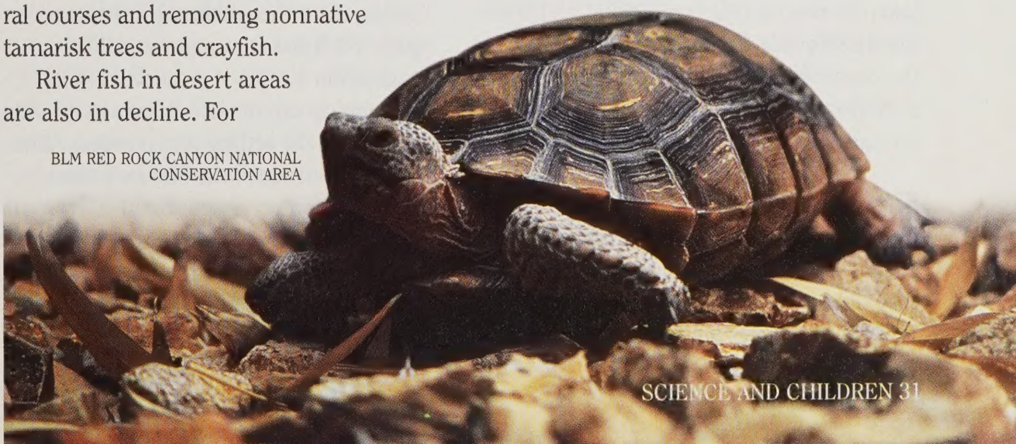
The Devils Hole pupfish (*Cyprinodon diabolis*), whose entire population lives in one small spring-fed pool in Nevada, has developed a physiology specifically adapted to the high temperature and salinity of this water. The Ash Meadows National Wildlife Refuge was created in 1984 to preserve the largest concentration of endemic plants and animals in one location in the United States. Twenty-four species, including the Devils Hole pupfish, have adapted to this unique salty desert environment and are found nowhere else in the world. Habitat restoration efforts include converting concrete irrigation ditches back to their natural courses and removing nonnative tamarisk trees and crayfish.

River fish in desert areas are also in decline. For example, native fish of the Colorado River, such as the Colorado squawfish (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*), have suffered population declines due to dams that have altered the temperature and flow of the river. Introduced sport fish also outcompete these native species.

Desert Tortoise

The desert tortoise *(Gopherus agassizii)* is a widespread desert species of the southwestern United States. Since its federal listing as a threatened species in large parts of its range, it has become a primary consideration in almost every activity that occurs in the Mojave Desert. Population declines are due primarily to disease, collection, raven predation, and loss of habitat as a result of urbanization. Other contributing factors include the spread of invasive species and human activities such as off-road driving, military maneuvers, and livestock grazing. These activities not only crush the tortoises and their eggs, they also destroy native plants that provide food, water, shade, and shelter. Urbanization causes habitat fragmentation, a serious problem as each tortoise may require access to up to 3.9 km^2 of habitat. Some desert tortoises also suffer from an upper respiratory disease, and ravens prey on hatchlings. Raven populations have increased in the Mojave as people have brought new food sources, such as landfills and garbage dumps, to the desert.

The BLM administers about 75 percent of the remaining high-quality desert tortoise habitat in the Mojave Desert. The agency is taking a lead role in tortoise habitat management, and has eliminated livestock grazing on almost a half-million hectares in Nevada alone. The BLM has designated these lands as Areas of Critical Environmental Concern, according them special protections.


BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

As a result of the desert tortoise's listing as threatened over much of its range, the welfare of the species is a primary consideration in almost all Mojave Desert management decisions.

Wringing Life Out of Every Drop of Rain

The Mojave Desert is an environment of extreme heat, poor soil nutrients, limited soil water-holding capacity, and—worst of all—little water. Even when rains come to the Mojave, often a great amount of water falls in a very short time onto ground so dry that the rain runs off quickly, washing away skimpy desert soil in the process. Sometimes, high temperatures cause rain to evaporate before it reaches the ground. Wind frequently compounds these challenges by rapidly evaporating scarce moisture and covering plants with dust.

Luckily, the Mojave's plant and animal species have developed ingenious physiological and behavioral adaptations that allow them to thrive in such a harsh world. Here are some examples of the complex ways in which Mojave species have adapted.

Plants

DORAN SANCHEZ, BLM

Many cacti and succulents take decades to reach maturity, and even then attain only a modest size. Barrel cactus growth takes place in spurts when abundant quantities of water are absorbed through its roots, though it is capable of subsisting on stored water alone for several years at a time.

Xerophytes are plants that have developed special means of storing and conserving water. To reduce transpiration, direct cooling air flow, shade themselves, and/or reflect hot sunlight, they often have few leaves, or have spines, thorns, or hairs instead; in some cases they use only their green "skin" to perform photosynthesis. Some xerophytes have leaves that are tough and waxy or coated with shiny oils, which also cuts down on transpiration, or they have small, fluttery leaves that help to cool the plants. Some species have spongy, shallow roots to take advantage of even the smallest amounts of rain, plant tissues that can store large amounts of water for later use, or ribs that direct moisture to the plant's roots. The Joshua tree (*Yucca brevifolia*), various types of cacti, and Mojave sage (*Salvia mojavensis*) are all examples of Mojave xerophytes.

U.S. GEOLOGICAL SURVEY

BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

Though the creosote bush may react to severe drought by dropping mature leaves or even whole branches, it always retains some younger leaves, which continue photosynthesis even under the most severe heat and drought conditions. After sufficient rainfall, miniature yellow flowers are followed by an abundant crop of dense, woolly seed balls, the fruit of the plant.

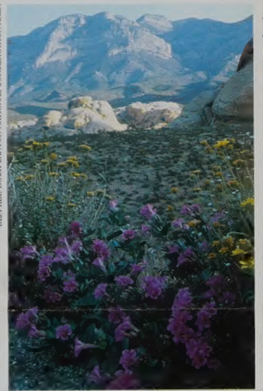
Phreatophytes are plants that grow extremely long roots, called *tap roots,* that allow them to obtain water from deep in the ground. Mesquites (*Prosopis* sp.) have the longest tap root of any desert species; it may reach down 25 m. The creosote bush (*Larrea tridentata*) is one of the most successful of all desert species because it uses a combination of several adaptations, including a deep tap root, a shallow root system, and wax-coated leaves that close their pores during the day to avoid loss of water. The creosote bush has the added advantage of being both bitter-smelling and -tasting; most animals won't eat it, and other plants often won't even grow near it, reducing competition for water.

DORAN SANCHEZ, BLM

Native Americans used the red, tangy-sweet blossoms of the ocotillo plant to make a beverage similar to lemonade.

Desert *perennials* survive by remaining dormant during dry periods of the year, then "coming back to life" when water becomes available. For example, the ocotillo (*Fouquieria splendens*) grows leaves quickly after a rain to produce food through photosynthesis. In a few weeks, ocotillo flowers bloom, seeds ripen and fall, leaves drop, and the plant becomes dormant once more. Ocotillo stems also have a waxy coating to help conserve water during dormancy. Other perennials include brittlebush (*Encelia farinosa*), some varieties of California poppy (*Eschscholzia californica*), and desert paintbrush (*Castilleja angustifolia*), a parasitic plant that appropriates water from its host.

By contrast, *annuals*, or *ephemerals*, germinate only after a heavy rain, and then complete their reproductive cycle very quickly to capitalize on optimal heat, light, and moisture conditions. They bloom profusely for a few days or weeks in the spring, and then die, leaving their drought-resistant seeds in the desert soils until the next spring rains. Annuals are responsible for the colorful desert wildflower displays that often appear in spring. Examples of such wildflowers are sand verbena (*Abronia villosa*), Mojave aster (*Xylorhiza tortifolia*), and dune evening primrose (*Oenothera deltoides*). Generally, thousands of annual and perennial seeds can be found in every handful of desert soil; the world record is over 200,000 seeds per square meter, though the Mojave's soils contain far fewer.


BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

Mojave Desert wildflowers such as these four o'clocks are alluring not only because of their extravagant beauty, but because of their rarity and unpredictability. After sufficient quantities of winter rain, sandy flats and lower hillsides throughout the desert may be carpeted with many different varieties of flowers in the early spring, with a second flowering possible after late-summer rains.

Animals

Desert animals are more susceptible to temperature extremes than are desert plants. Animals receive heat directly by radiation from the sun, and indirectly by conduction from the substrate (rocks and soil) and convection from the air. The biological processes of animal tissue can function within a relatively narrow temperature range called the *range of thermoneutrality*, so in the Mojave animals must employ strategies not only to obtain water but also to avoid or moderate the heat. Luckily, animals have an advantage over plants in that animals can move.

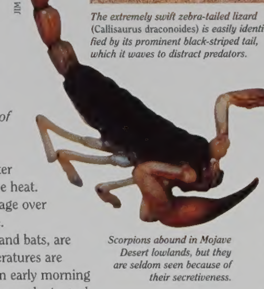
Some animals, such as owls and bats, are active only at night when temperatures are lowest. Animals that are active in early morning or at dusk, such as lizards, snakes, rodents, and insects, seek shelter in cool, moist burrows during the heat of the day or hide themselves under rocks or bushes. Birds such as eagles can literally rise above the heat, finding cooler temperatures by flying high above the surface. Still other species, most often birds, migrate to cooler climates for the hottest portions of the year, returning to breed in the Mojave when temperatures are lower.

There is also a desert equivalent to hibernation, called *estivation*. For example, during hot dry spells, the spade-foot toad (*Scaphiopus* sp.) covers itself with a substance to stay moist and then enters an underground burrow, where it can survive for many months until heavy rains signal it to wake. After mating and laying eggs in temporary pools, the toads return to their burrows and resume estivation until the next heavy rains. The desert tortoise (*Gopherus agassizii*) also estivates; it eats cacti, grasses, and wildflowers from March until June, and then retreats to an underground burrow for the heat of the summer. In the cooler fall, the tortoise emerges to eat and drink. Some desert squirrels and spiders also estivate in response to food scarcity.

Owls often gape open-mouthed and flutter their throat area to cool themselves by evaporating water from the mouth cavity, and vultures sometimes expel urine onto their legs to cool themselves through evaporation; however, these two approaches are only practical for animals that receive plentiful supplies of water from the prey they consume.

ROSS HALEY, U.S. FWS

The adult desert tortoise's hard shell and thick skin protect it from dehydration as well as from attacks by predators.

JIM WILLIAMS, U.S. FWS


Scorpions abound in Mojave Desert lowlands, but they are seldom seen because of their secretiveness.

BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

The extremely swift zebra-tailed lizard (Callisaurus draconoides) *is easily identified by its prominent black-striped tail, which it waves to distract predators.*

Some Mojave animals have developed special physiological structures to enable them to regulate body heat. Mule deer and jackrabbits, for example, have large ears that are densely lined with shallow blood vessels, allowing air to cool their blood as it circulates. Some small creatures, such as beetles and lizards, reduce the amount of heat they absorb from the desert surface by having long legs to keep them high up and to disperse heat. Pale-colored fur and feathers help others to keep cool by reflecting sunlight.

Mojave animals also have many different approaches to obtaining and conserving water. Some rodents and insects get water by consuming cacti and other plants, and bats obtain it by eating insects. Snakes ingest water when they consume prey animals such as rodents and conserve it by excreting metabolic wastes as solid uric acid rather than liquid urine. When there is no outside water available, desert tortoises are able to reabsorb the water stored in their bladders.

It is even possible for some animals, such as kangaroo rats (*Dipodomys* sp.) and pocket mice (*Perognathus* sp. and *Chaetodipus*, sp.) to get water by using dry seeds. They store the seeds in their burrows, where the seeds absorb moisture from the air; the animals then receive that moisture when they eat the seeds. Kangaroo rats are even able to manufacture water as a byproduct of chemical processes involved in their digestion of seeds, and they seal their burrows to recycle the moisture released during breathing. These creatures are so efficient in their use and conservation of water that even in captivity they will not drink water when offered it.

GEORGE HARRISON, U.S. FWS

The kangaroo rat excavates labyrinthine underground galleries where it lives in cool comfort during hot desert days.

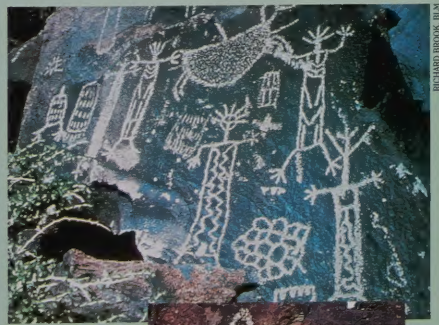
The desert bighorn sheep (*Ovis canadensis*) is an example of a Mojave animal that is somewhat reliant on springs, rivers, puddles, and other outside sources of water, since it receives limited moisture from the food it eats and has developed no special accommodations in this regard. This is especially true in winter when vegetation is dormant and dry. Reliance on outside sources of water means that the bighorn's territory, and that of most other large desert mammals, is limited by distance from such water sources.

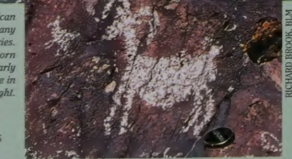
BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

Desert bighorn sheep are the largest native mammals in the Mojave Desert, with mature rams sometimes reaching 115 kg in weight. These amazingly surefooted animals have been known to leap 10 m down a steep incline and land with perfect accuracy.

Early Peoples of the Mojave Desert

Recently, Mojave Desert *petroglyphs* (rock pictures) have played an important role in debates about the age of the first human occupation of the New World. New dating results show that *Paleoindians* may have reached this area as long as 15,500 years ago. No associated *habitation* sites have yet been discovered in the Mojave, however, which suggests that these prehistoric peoples moved from place to place. Over time human settlement patterns became increasingly organized, with more complex rituals and a subsistence reliant on seeds, plants, and farming. Small-game hunting contributed meat protein to the peoples' diet.

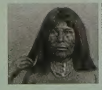

RICHARD BROOK, BLM


RICHARD BROOK, BLM

Native American petroglyphs depict many different Mojave species. The desert bighorn sheep has a particularly prominent place in the photo at right.

Several tribal groups have lived in the Mojave Desert within the past 2,000 years. The northern and eastern portions, for example, were occupied by the Kawaiisu, Kitanemuk, Serrano, and Koso, and Southern Paiute bands, including the Chemehuevi. Culturally distinct, these groups nevertheless spoke related languages and had similar socioeconomic systems. Resource gathering was done in family groups over wide areas, but for at least part of each year life centered on more permanent villages. The tribes knew much about Mojave Desert resources, enabling them to gather supplies from all portions of their territories. They generally had friendly relationships with neighboring groups such as the Mojave, though they also experienced episodes of intertribal hostility.

The Mojave Indians made pottery from clay and crushed sandstone, decorating their creations with geometric designs. The art of tattooing was also important to the Mojave, who frequently adorned their faces with dark lines and dots. They were famous travelers, regularly making 500 km trips to the Pacific Coast to trade pottery and other goods for seashells and beads. Mojave legend holds that tribal runners could cover the distance in only a few days, traveling by way of perennial springs and the Mojave River.


NATIONAL PARK SERVICE

This Mojave Indian woman, photographed in Needles, California, in 1883, displays the intricate facial tattooing once so esteemed by the Mojave people.

The Chemehuevi tribe spoke a different language from that of the Mojave Indians. They occupied a particularly barren portion of the Mojave Desert and wrested a rough living from the open land. Like their Mojave neighbors, the Chemehuevi were highly mobile, making use of resources throughout their large territory; however, they also had settlements to which they returned regularly. To transport goods and for other purposes, they created complex, beautiful baskets from reeds and grasses. Like other Southern Paiute groups, they sometimes worked small farms.

Fortune hunters were the first outsiders to venture into the Mojave Desert, at a time when the Mojave Indians were the largest concentration of people in the Southwest. But it wasn't until 1775 that Francisco Garcés, a Spanish Catholic missionary, became the first European to meet the Mojave Indians, who accompanied Garcés on his journey to the coast. Garcés's route, which also took him through Chemehuevi lands and was documented in great detail in his diary, became known to later travelers as the Mojave Road.

American "mountain men," led by the legendary Jedediah Smith, appeared in Mojave Indian territory in 1826, and though tribe members first welcomed the trappers, conflict was not long in coming. In 1827, another trapping party came through Mojave land, ignoring the tribe's requests for goods in exchange for trapped animals. The resultant conflict left victims on both sides. When Smith returned later that year, his party was also attacked, and for the next 20 years violence reigned, reaching a peak when trappers from the Hudson Bay Company killed 26 Mojaves.

In 1850, southwestern territory was annexed by the U.S. Army, the beginning of military encroachment on the region. New transportation routes were critical to an expanding nation, and a wagon trail was opened. In 1858, the first wagon train en route to California was attacked when it lingered at the Colorado River crossing near present-day Needles. Spurred by public outcry, Indian fighters were sent to the area from San Francisco. Though there was no combat and the Mojave claimed no responsibility for the wagon attack, prominent tribe members were jailed and the army established Ft. Mojave at the crossing. When several Mojaves escaped from prison, soldiers hunted them and others, eventually banishing the tribe from its homelands near the river crossing.

In 1865, the U.S. Government created the Colorado River Indian Reservation near Parker, Arizona, an area of poor farmland. Favoring peace, the new Mojave chief guided hundreds to the reservation, while the former chief remained to lead those who refused to leave their homeland; the tribe was effectively split into two. A compulsory education law for Indians was passed, partly to eradicate native language and culture. The Mojaves were taught American farming methods, though they had no suitable land of their own. Many turned to the railroads for work, others labored on riverboats, and some sold crafts to tourists. During this same period the remaining Chemehuevi were forced onto reservations in California.

NATIONAL PARK SERVICE

Many late 19th-century Mojave Indians sought work with the railroads after being forced from their tribal lands.

Traditional Mojave tribal leadership was changed forever in 1957, with the creation of a seven-member tribal council. The Mojave Desert's current resident populations of Mojave and Chemehuevi Indians, collectively numbering less than 2,000, live on reservations in California, Nevada, and Arizona. Today many local tribes are united as the Colorado River Indian Tribes and the Colorado River Native Nations Alliance.

Mojave Desert, Here We Come!
Miners, Homesteaders, and Route 66

During the mid-19th century, mining in all areas of the Mojave created boom towns with colorful names and characters. On Christmas Day in 1860, for example, the first producing Mojave mine, named "Christmas Gift," was opened in Death Valley. As the mining boom continued, borax—"the white gold of the desert"—was discovered; it has been mined profitably in the Death Valley area since. During the 1870s, the Clark Mountain Mining district was established and with it the town of Ivanpah, which at the time was the only American community of any size in the eastern portion of the Mojave.

Gold was discovered in El Dorado Canyon in the late 19th century, where a single mine ultimately produced $1.7 million in gold. Small prospectors, however, generally made very little money, the biggest problem being the costs of transporting supplies to such remote locations. "Boom-or-bust" mining was the usual approach: As soon as a strike played out, miners moved on, leaving ghost towns in their wake.

With the coming of the Santa Fe Railroad, water and other supplies were made available to companies intent on capitalizing on the Mojave's resources. In the early 1900s, more mines were open and profitable in the Mojave than at any previous time, establishing such towns as Cima, Kelso, and Fenner. Demand for Mojave metals such as gold, silver, and manganese, peaked during World Wars I and II. Today most Mojave mining is for gold and nonmetals such as borax.

U.S. GEOLOGICAL SURVEY

Developed in California's Ivanpah Valley in the mid-1980s as a small, open-pit, heap-leach operation, the now-abandoned Morningstar Gold Mine has the potential to cause cyanide-related environmental problems.

Beginning in 1910, land was homesteaded in the Mojave Desert, usually in 64.8 ha (160 ac) parcels. Claimants had three years in which to improve their properties to receive a deed from the General Land Office, a predecessor of the Bureau of Land Management. Among the Mojave homesteaders were sizeable numbers of Black pioneers, who came from other parts of California to settle in the Lanfair Valley area. For a few years after 1912, rainfall was relatively plentiful, and crop production was vigorous enough that more people were attracted to the area. Mustard-gas victims of World War I also came to take advantage of the benefits of the dry desert air.

NATIONAL PARK SERVICE

A Mojave Desert homesteader poses at California's Lanfair Valley railroad station, which was served by the Nevada Southern Railway. A branch railroad of the Atchison, Topeka, and the Santa Fe Railway until it closed in 1923, the Nevada Southern line was the main economic lifeline of the high country in the eastern Mojave.

Ultimately, the rains didn't last, and water rights conflicts erupted between homesteaders and ranchers. In many cases, after digging unsuccessful water wells, homesteaders were forced to haul water for several kilometers for household use. Many small farms and homesteads were abandoned with only tiny cabins left behind.

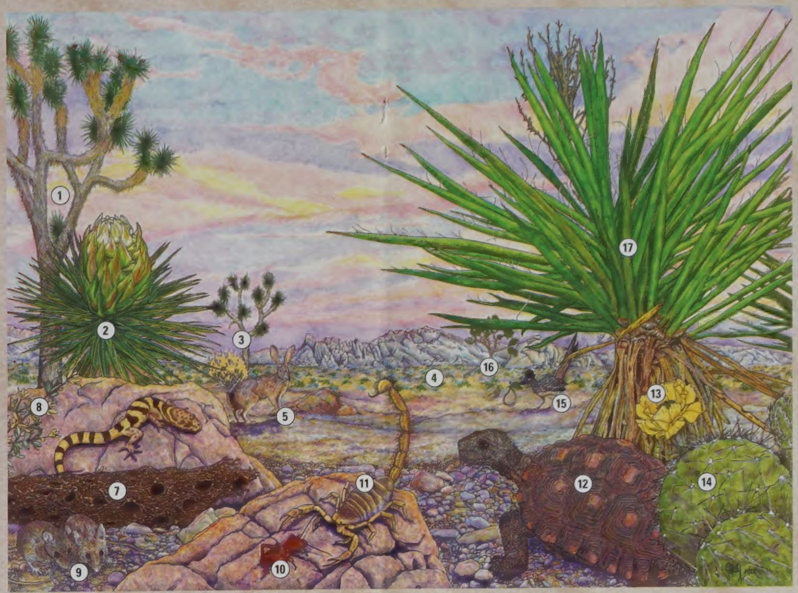
During the 1920s, Route 66 appeared out of a desire to improve the road network in the West, which featured a hodgepodge of tracks and trails that had been established by American Indians and pioneers. A descendant of the early 1900s "National Old Trails Road," the new two-lane route would join the Midwest to California. Route 66 was also to become a legend—"the Mother Road" and "the Main Street of America"—immortalized in John Steinbeck's *The Grapes of Wrath*, Nat King Cole's "(Get Your Kicks on) Route 66," and a popular 1960s television show.

During the Great Depression of the 1930s migrants sought out the Mojave as an area where they might be able to grow their own food without regard for unstable world markets. Sandstorms and drought drove millions from the Dust Bowl toward California on Route 66. During and after World War II Americans traveled the route heavily, though the roadway was narrow and accidents frequent. In 1956 interstate highways, including Routes 40, 15, and 10 through Arizona and California, began to skirt around the towns along Route 66 closely paralleling the older route. By 1985 the last of these, Williams, Arizona, was bypassed.

It is no longer necessary to drive any part of Route 66 to reach California from Chicago. However, a new generation of travelers has made a hobby of tracing authentic pieces of the highway, following the "Historic Route 66" signs that began appearing in 1995 in all of the route's eight states.

GORDON WARREN, BLM

As Historic Route 66 meanders through the Black Mountains of western Arizona, it presents travelers with hairpin curves and steep grades—some of the most fearsome obstacles along its length



Mojave Springtime [guide to the poster]

A spring Mojave sunset finds the hillsides in bloom and the desert's denizens active in the relative coolness. In the right foreground, a desert tortoise (12) emerges from the cover of a prickly pear cactus (14), whose yellow flower (13) presents a graceful contrast to the cactus's thorn-studded "skin." Above them a Mojave yucca (17) spreads stiff, bayonet-like leaves toward the sky, while a roadrunner (15) beyond it holds a snake (its meal) in its bill. The tortoise eyes a giant desert hairy scorpion (11), its raised tail stinger threatening a Jerusalem cricket (10), a potential meal. Two mice (9) in the left foreground huddle beside the skeleton of a dead cactus (7), while a western banded gecko (6) clings to a rock near a flowering creosote branch (8). Above the rock, a whitish Joshua tree bloom (2) graces a spiny branch tip, while a taller tree (1) stands sentinel. Further in the background a black-tailed jackrabbit (5) appears ready to bound away through landscape studded with more creosote bush (4) and Joshua trees (3, 16).

SCIENCE
& CHILDREN

© Copyright 2001 by the
National Science Teachers Association

Did you know that . . .

. . . the Creosote Bush (*Larrea tridentata*) produces an antibiotic against staphylococcus, diphtheria, and typhoid bacteria?

. . . the roots of the Coyote Melon (*Cucurbita palmata*) were used by Native Americans as a source of soap?

. . . during World War I, 7.2 million metric tons of burlap were made from the leaf fiber of Mojave Yucca (*Yucca schidigera*)?

. . . Pickleweed (*Allenrolfea occidentalis*) grows in water that is *six times* saltier than ocean water?

. . . the stem sap of the Rubber Rabbitbush (*Chrysothamnus nauseosus*) contains almost three percent rubber?

. . . early Mormon settlers named *Yucca brevifolia* the "Joshua Tree" because they thought it appeared to be lifting its "arms" to heaven, like the biblical prophet Joshua?

. . . the Rock Nettle (*Eucnide urens*) is covered with stinging "hairs" so formidable that bats have reportedly impaled themselves on plants growing outside cave entrances?

BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

Mojave yuccas reach heights of 1 to 3 m.

Activities

Mixing It Up

This activity aligns with the following National Science Education Standards: *Content Standard C: Life Science–Populations and Ecosystems* and *Content Standard D: Earth and Space Science–Structure of the Earth System.*

Background

A variety of human activities pose serious threats to life in the Mojave Desert. Use of desert lands for livestock grazing can strip land of most of its vegetation. Farming and urbanization both result in increased use of groundwater that can leave desert plants and animals without the water they need to survive. The growing popularity of off-highway vehicles (OHVs) causes further damage to plants and fragile desert soils. When desert plants are damaged, the thin soil begins to erode, making the area unsuitable for living things. Once the damage is done, the process of recovery is extremely slow. There are many reasons for this, including temperature extremes, sunlight intensity, high winds, and lack of rainfall. Another factor is the sparse vegetation that is characteristic of the desert. Fewer plants mean less *humus*, which is formed from the decomposed remains of plants and animals. Humus provides many of the nutrients plants need to survive.

By examining the composition of soil and making soil mixtures of their own, we can begin to understand ways in which soil contributes to plant growth and the long process that is involved in its formation. We'll also come to appreciate why it's important to protect the thin, fragile layer of soil in the desert.

U.S. GEOLOGICAL SURVEY

The Mojave's native species must often share the desert's resources with domestic livestock such as sheep and cattle whose grazing and hooves may damage vegetation and the landscape.

BLM RED ROCK NATIONAL CONSERVATION AREA

Desert pavement is composed of gravel and small rocks overlaid with delicate desert varnish that may take thousands of years to form.

Materials Needed

- natural soil samples, at least 0.25 L per student, collected from several outdoor locations (make sure you have permission to dig samples if you're not digging on school property)
- an assortment of "ingredients" for students to make their own soil mixtures, such as leaves, small rocks, broken shells, sand, clay, grass clippings, small sticks, etc., (assemble enough so that each student will be able to make about 0.5 L of soil)
- water
- plastic trays, cardboard box tops, or sections of newspaper, at least 25 cm by 40 cm
- containers of varying sizes, such as large coffee cans and plastic cups or planting pots, with a capacity of at least 0.25 L
- hand lenses, spoons, toothpicks, and other "excavating" devices
- fast-germinating seeds, such as zucchini, beans, zinnia, and cosmos

Procedure and Questions

1. Students spread samples of the natural soil out on plastic trays and use hand lenses to examine them. Can they see pieces of rock or sand? Any living things? Encourage students to smell and feel their soil samples as well, and to describe their samples as precisely as possible.
2. Remind students that soil contains both organic and inorganic materials and that its formation involves a long, complex process.
3. Next, students develop their own "recipes" for soil mixtures that they think will be capable of supporting plant life. The goal should be to produce about 0.5 L of soil mix. One approach could be to divide the class in half, with one group of students attempting to replicate desert soil and the second group working on mixtures that are more likely to be found in a forest environment. Before they begin mixing their ingredients, students need to consider the following questions:
   - How would the balance of ingredients differ between forest soils and desert soils? (Desert soils would contain more sand, while forest soils are likely to contain more organic matter and, depending on where they come from, possibly more clay.)
   - What ingredients would provide organic matter to plants? (From the above list of materials, leaves, grass clippings, and sticks would provide organic matter.)
   - What ingredients would provide minerals? (rocks and shells)
   - What materials would improve drainage? (sand and other larger particles)
   - What materials would help retain water? (clay and other smaller particles)
   - What materials would help anchor plant roots? (clay)

   Following a discussion of these questions, students adjust their recipes if they wish.
4. Students then combine their ingredients to make the soil, adding a few tablespoons of water to each mixture. Stir until the ingredients are thoroughly moistened.
5. Discuss with the class the ways in which their mixtures are similar to and differ from the natural soil samples they examined in Step 1. What might account for differences? (Answers will vary depending on where the natural samples came from and what ingredients were used in students' recipes, but the major factor accounting for differences is time: The natural processes that create soil occur slowly.)
6. How do students think plants will grow in the soils they made? To test their ideas, have students put their soil mixtures into plastic pots and plant seeds in them. Seeds should also be planted in the natural soils for comparison. Place all the pots in a well-lighted area, and water every couple of days with equal amounts of water.

Keeping Cool

This activity aligns with the following National Science Education Standard: *Content Standard C: Life Science – Diversity and Adaptations of Organisms*

Background

Desert animals have developed many ways to cope with the heat and sun. Many come out only at night or during the early morning and late evening. They spend their days in the shade or they burrow into the sand, where temperatures are cooler. Students can easily test the value of such strategies by measuring temperature differences in the schoolyard or in their own backyards.

Materials Needed

- two indoor-outdoor or classroom thermometers, 15–20 cm long
- 5 kg of sand
- a deep box or small wastebasket, about 15 L in capacity
- plenty of sunshine

Procedure and Questions

1. Students place one thermometer out in the bright sun for at least an hour, and a second one in the shade of a tree or large boulder for the same length of time. (Make sure that this second thermometer stays in the shade for the entire testing period.) At the prescribed time, read the temperatures on the two thermometers. Students should discover that the temperature in the shady area is considerably lower than that in the sunny location.
2. Next, fill the box or small wastebasket with sand. The sand should be about 25–30 cm deep. Put the container in an area where the sun will shine on it all day. In the afternoon, push the end of one thermometer just slightly into the sand. After a minute or so, record the temperature. Place the second thermometer deep in the sand. Again, wait about a minute and record the temperature. How much lower is the temperature beneath the sand?

Extension

Assign each student or student group a specific desert animal to research and report on. Students should focus on ways in which their animal is adapted to its environment. Students should be encouraged to use the Internet as a resource in their research; some good websites to use as starting points are: Mojave National Preserve–Desert Plants and Animals at *www.nps.gov/moja/mojaan.htm*; Life in the Desert at *http://natureexplorer.com/LD/LD1.html*; and Desert USA-Desert Animals and Wildlife at *www.desertusa.com/animal.html* the desert's limited supply of biodegradable materials (or *biomass*), intense solar exposure, and low moisture.

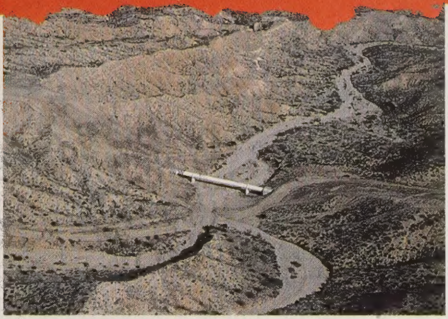
Vehicles can also cause direct damage by running over and destroying plants and even animals such as lizards and tortoises, or crushing the underground burrows where tortoises often spend much of the day. As a result, OHV use is managed by federal agencies to keep vehicles away from the most fragile areas, while allowing OHV activities on more durable surfaces, such as barren sand dunes or clay flats. In most cases OHV use is confined to designated roads and trails; some areas are fenced to keep vehicles out of sensitive habitat. Other areas, such as the Desert Tortoise Research Natural Area near Ridgecrest, California, and designated wilderness areas within the Mojave, are closed to OHV use altogether. In many areas of the Mojave the BLM has implemented OHV policies that require active management of sensitive areas.

Balanced management helps prevent OHVs from stirring up and loosening thin desert topsoil layers—which accelerates erosion—or destroying *microbiotic crusts*, thin soil surface layers bound together by living microorganisms, including lichens and algae. At the same time, management of OHV access avoids soil compaction and the creation of hardened "roadways."

Extensive military exercises that entail the movement of heavy equipment also can have serious impacts on desert soils similar to, but much more intensive than, those caused by OHVs. The U.S. Army, Air Force, Marine Corps, and Navy all operate major training or testing facilities in the Mojave Desert. The Department of Defense is working with the Department of the Interior to reduce the impact of its activities.

Utility Corridors

Because the Mojave Desert is sandwiched between high-tech, urban areas, there is an increasing need to connect these areas with new fiber-optic telecommunications lines and other utility services. Often these utility rights-of-way bisect wildlife habitat, causing weeds to spread and reducing species diversity. Land managers are working with utility companies to reduce these impacts by establishing right-of-way corridors along already established routes and by limiting new routes.


U.S. GEOLOGICAL SURVEY

Constructed in the 1960s, the Los Angeles Aqueduct carries water from Owens Valley, Nevada, to Los Angeles, California. The land's recovery from the aqueduct's burial is still incomplete as evidenced by the nearly barren surface strips extending from either end of this exposed portion of the pipeline where it crosses a canyon.

Sensitive Fish Species

With water in diminishing supply, desert fish species face great peril. In fact, more than half of the native desert fish species in the Mojave are either federally listed as threatened or endangered or are species of concern. An estimated eight percent are already extinct. Native desert fish often are specifically adapted to the heat and elevated salinity of the water, particularly those species that evolved in small, isolated springs.

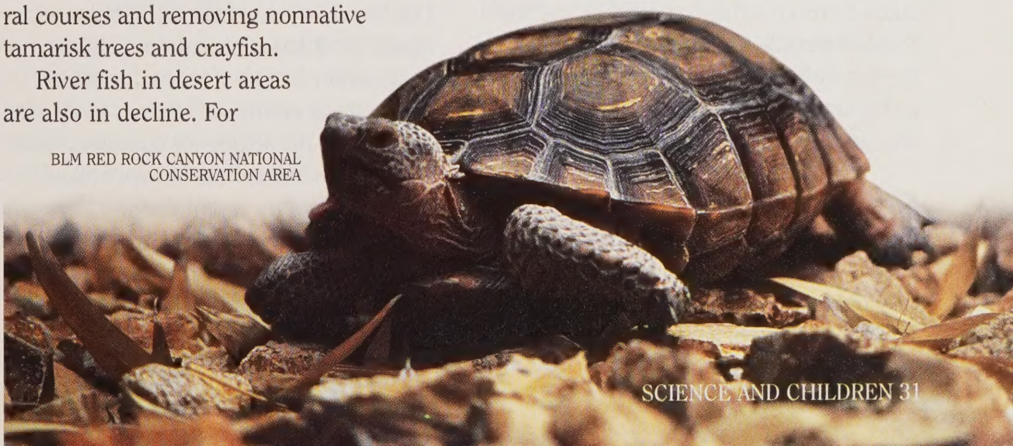
The Devils Hole pupfish (*Cyprinodon diabolis*), whose entire population lives in one small spring-fed pool in Nevada, has developed a physiology specifically adapted to the high temperature and salinity of this water. The Ash Meadows National Wildlife Refuge was created in 1984 to preserve the largest concentration of endemic plants and animals in one location in the United States. Twenty-four species, including the Devils Hole pupfish, have adapted to this unique salty desert environment and are found nowhere else in the world. Habitat restoration efforts include converting concrete irrigation ditches back to their natural courses and removing nonnative tamarisk trees and crayfish.

River fish in desert areas are also in decline. For example, native fish of the Colorado River, such as the Colorado squawfish (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*), have suffered population declines due to dams that have altered the temperature and flow of the river. Introduced sport fish also outcompete these native species.

Desert Tortoise

The desert tortoise *(Gopherus agassizii)* is a widespread desert species of the southwestern United States. Since its federal listing as a threatened species in large parts of its range, it has become a primary consideration in almost every activity that occurs in the Mojave Desert. Population declines are due primarily to disease, collection, raven predation, and loss of habitat as a result of urbanization. Other contributing factors include the spread of invasive species and human activities such as off-road driving, military maneuvers, and livestock grazing. These activities not only crush the tortoises and their eggs, they also destroy native plants that provide food, water, shade, and shelter. Urbanization causes habitat fragmentation, a serious problem as each tortoise may require access to up to 3.9 km^2 of habitat. Some desert tortoises also suffer from an upper respiratory disease, and ravens prey on hatchlings. Raven populations have increased in the Mojave as people have brought new food sources, such as landfills and garbage dumps, to the desert.

The BLM administers about 75 percent of the remaining high-quality desert tortoise habitat in the Mojave Desert. The agency is taking a lead role in tortoise habitat management, and has eliminated livestock grazing on almost a half-million hectares in Nevada alone. The BLM has designated these lands as Areas of Critical Environmental Concern, according them special protections.


BLM RED ROCK CANYON NATIONAL CONSERVATION AREA

As a result of the desert tortoise's listing as threatened over much of its range, the welfare of the species is a primary consideration in almost all Mojave Desert management decisions.

GARY M. STOLZ, U.S. FISH AND WILDLIFE SERVICE

Desert bighorn sheep are usually found near "escape terrain" (steep, rocky slopes free of dense brush) where they are capable of evading almost any predator. This tendency sometimes results in the isolation of groups of individuals when human activities encroach.

To both accommodate urban growth and protect the tortoise, a team of federal, state, county, city, and private partners has developed a special "habitat conservation plan" to help streamline compliance with federal and state endangered species laws. This has allowed continued development around Las Vegas and other areas in Clark County, Nevada, while raising millions of dollars in mitigation fees to support broad conservation and research efforts. One result is the Desert Tortoise Conservation Center, located on public lands south of Las Vegas, which supports critical research on the species.

Under BLM leadership, an interagency habitat conservation plan is also being prepared for a 3.8 million hectare region within the western Mojave. The plan addresses the conservation needs of over 100 sensitive species in the face of rapid development of suburban Los Angeles.

The desert bighorn sheep will also benefit from desert tortoise habitat recovery efforts. Like the tortoise, its population has suffered as a result of habitat fragmentation. It also could not compete with domestic livestock and wild burros for food and water. Its numbers declined precipitously in the Mojave Desert until about 20 years ago, when steps were taken to reverse this trend. BLM and the State of Nevada have now reintroduced the desert bighorn sheep to most of its former range in Nevada, and managers are cautiously optimistic about its future.

Fire and Weeds

Fires historically were not common in the Mojave Desert, and when they did occur, they did not spread rapidly or very far. The natural spaces left between native desert plants usually kept fires under control. Today these spaces are increasingly filled by nonnative grasses, such as cheatgrass (*Bromus tectorum*) and red brome (*Bromus rubens*), which remain rooted after they die, creating an uninterrupted fuel source for fires. (By contrast, native desert annuals crumble and blow away after they die.) Nonnative grasses also are the first to emerge after a fire, giving them a competitive edge. The result is weed-infested landscapes. In the Mojave, land managers now suppress fires when possible to inhibit weed growth.

Tamarisk (*Tamarix chinensis*), another desert alien, is one of the most invasive shrub-trees in the southwestern United States. Also known as saltcedar, it destroys riparian habitats, taking in great amounts of water and depositing salt into the soil. The plant also fuels fires with its large masses of dry branches and leaves. After a fire it quickly re-sprouts and easily outcompetes native plants because of the salt it has deposited into the soil. Tamarisk also has an advantage because the Mojave's native cottonwood and willow trees need periodic floods to survive, a natural process that has been virtually eliminated by modern water control projects. Most riparian areas in the desert are therefore dominated by tamarisk.

Complicating removal of tamarisk is the situation of the endangered southwestern willow flycatcher (*Empidonax traillii extimus*), a bird that has turned to the tamarisk for shelter because of the destruction of its native cottonwood and willow habitat. This poses a special challenge for managers, who must take care not to disturb this endangered species as tamarisk is removed.

Rising to the Occasion

The Mojave is the smallest North American desert, yet it has captured the public's imagination far out of proportion to its geographical extent. And thanks to its wide exposure as the setting for countless films and advertisements, the Mojave's allure has only grown in recent decades.

As more people seek escape from the congestion of nearby urban centers, the Mojave Desert, paradoxically, has become an oasis for many diverse groups, from hikers and ranchers, to biologists and OHV riders. Each type of user prizes this unique ecosystem for different—and sometimes conflicting—reasons.

Fortunately, Mojave users have begun to agree that this harsh landscape is at the same time a deceptively fragile one, harboring ecological riches found nowhere else on Earth. Federal agencies and other government groups are making inroads into reversing environmental damage inflicted over generations of past use, and private citizens are volunteering in growing numbers to help conserve the Mojave's treasures. The encouraging results of many such efforts offer lessons about what can be accomplished when people and organizations work collaboratively for common conservation goals.

The one-of-a-kind world of the Mojave undoubtedly has countless hidden treasures to reveal and important lessons still to offer. As its guardians, citizens and governments must work to ensure that the Mojave will survive intact to impart its wisdom for millennia to come.

DORAN SANCHEZ, BLM

Prescribed burns (purposely set, controlled fires) are sometimes used in the Mojave Desert to remove tamarisk overgrowth and improve riparian habitat.

S. AND D. MASLOWSKI, U.S. FWS

The endangered southwestern willow flycatcher uses nonnative tamarisk for shelter. Population declines are due in part to cowbird parasitism. Female brown-headed cowbirds (Molothrus ater) *lay their eggs in the flycatchers' nests, and the stronger and more aggressive cowbird hatchlings often kill the young songbirds. Because cowbirds are typically associated with and follow cattle, land managers are altering grazing regimes during flycatcher-breeding seasons.*

For the Classroom

Mapping Deserts

This activity aligns with the following National Geography Standard: Standard 8: The Characteristics and Spatial Distribution of Ecosystems on Earth's Surface

Background

Many people think of deserts as vast expanses of blowing and drifting sand. As the Mojave illustrates, deserts are anything but one-dimensional. All deserts feature very low precipitation levels, but they can be hot or cold, sparsely vegetated or full of life. Most deserts occur between the latitudes of 15° and 40° on either side of the equator. They cover approximately 20 percent of the Earth's land area. There are several types of deserts, categorized on the basis of the conditions that created them.

Subtropical deserts lie along the Tropics of Cancer and Capricorn. Near the equator, hot, moist air rises and then cools, dropping heavy rains on tropical areas. The resulting cooler, drier air then descends, creating zones of high atmospheric pressure as the air moves away from the equator. The descending air hinders cloud formation and precipitation. The air also warms up as it sinks, absorbing any available moisture. Africa's Sahara Desert is the best-known example of a subtropical desert.

Coastal deserts also develop because of high-pressure weather systems. Damp, chilly fog forms when air cooled by water contact as it blows toward shore meets warm air over land. Although humidity is high, atmospheric disturbances that cause rainfall are not present. The Atacama in Chile and the Namib in southern Africa are both coastal deserts.

Interior deserts, such as Asia's Gobi Desert, exist because they are too far from the ocean. By the time ocean winds reach the center of a large landmass, their air is very dry.

Rain shadow deserts are created when mountain ranges lie parallel to moist, coastal areas. Prevailing winds moving inland cool as air is forced to rise over the mountains. Moisture falls on slopes facing the winds. When the winds move over the mountain crests and down the far side, they are very dry. Descending air also makes it hard for additional clouds and precipitation to form. Without another source of moisture, rain shadow deserts are formed on the far side of these mountains. As mentioned in the article, the Mojave is a rain shadow desert.

Procedure

Assign small groups of students to research and report on some of the world's deserts. In their reports, groups should locate their desert on a world map, describe its physical features and the way in which it was created, and if possible, include illustrations of typical plants and animals. Students should be encouraged to use the Internet as a resource in their research; some good websites to use as starting points are: The World's Biomes: Deserts at *www.ucmp.berkeley.edu/glossary/gloss5/biome/deserts.html* and Desert Biome at *http://mbgnet.mobot.org/pfg/diverse/biomes/desert/index.htm*.

Earthshaking Events

This activity aligns with the following National Science Education Standard: Content Standard D: Earth and Space Science – Structure of the Earth System

Background

A fault is a fracture in the Earth's crust along which rocks on one side have been displaced in relation to rocks on the other side. Earthquakes are caused by the release of large amounts of energy as one or more rock masses under stress shift or slide past each other suddenly along a fault. Because the Mojave Desert region is being crushed between the Pacific and North American tectonic plates, it experiences relatively frequent earthquakes along many different faults.

Scientists use seismographs to record earthquake vibrations. These instruments help scientists determine the location of an earthquake and its strength, or magnitude. Students can make their own version of a seismograph to see how it works.

Procedure

1. Place a chair approximately 50 cm in height on top of a table.
2. Using a string and masking tape, suspend an uncapped, fine-tip marker from the seat of the chair. Adjust the length of the string so that the tip of the marker just barely reaches the tabletop.
3. Next, take a strip of adding-machine tape about 75 cm long and center one end of it beneath the marker.
4. Now, let the shake, rattle, and roll begin. Have one or two students gently shake the table from side to side, while another slowly pulls one end of the adding machine tape lengthwise under the marker. The students shaking the table should gradually increase the force of the quaking.

Question

What happens to the marks on the tape as the shaking increases? (The marker tracings extend further and further on both sides of the paper's center line.)

Weed Invaders

This activity aligns with the following National Science Education Standard: Content Standard C: Life Science – Populations and Ecosystems; Diversity and Adaptations of Organisms

Background

To teach how competition with weeds can threaten the survival of native plants, have students set up some plant competitions in the classroom. You'll need three medium-sized pots filled with potting soil.

Procedure

1. In the first pot, plant a handful of quick-germinating grass seed, such as wheat, barley, oats, or rye. In the second, plant a half dozen or so flower seeds, such as marigolds or zinnias. In the third pot, plant a mixture of the grass and flower seeds.
2. Cover the seeds in each pot with a thin layer of potting soil.
3. Place the three pots next to each other in a sunny location and water each pot regularly, using equal amounts of water.
4. Once a week over the course of four to six weeks, have students monitor the growth in each of the pots, measuring the height of the grass and the flower stems.

Questions

Which flower plants appear healthier after several weeks? (Among characteristics students can look for are: height, overall color, and number and size of leaves. The flowers planted separately should appear healthiest.) Why? (These flowers had full access to water and to the nutrients in the soil.) Describe the grass in the two pots. (The grass planted alone should appear healthiest, but the grass planted with the flowers should also appear healthy.) Why is the grass in the pot with the flowers likely to be healthier than the flowers in the same pot? (Its root system is more extensive and often grows faster than the plant's root system, making it better able to take in water and nutrients.) Explain that this is similar to what happens in the desert, where native annual flowers are reduced when nonnative grasses such as cheatgrass are introduced.

References, Resources & Acknowledgements

Teacher Resources

- U.S. Geological Survey, Mojave Desert Ecosystem Science Program *http://wrgis.wr.usgs.gov/MojaveEco*
- U.S. Geological Survey, Deserts: Geology and Resources *http://pubs.usgs.gov/gip/deserts/contents*
- National Park Service, Mojave National Preserve *www.nps.gov/moja/ home.htm* and *www2.nature.nps.gov/grd/parks/moja*
- National Park Service, Mojave National Preserve Revised (2000) Draft Environmental Impact Statement and General Management Plan *www.nps.gov/moja/planning/mojarevisedplan*
- National Park Service, Death Valley National Park and Joshua Tree National Park *www.nps.gov/deva/Expanded.htm* and *www.nps.gov/jotr/desert/desert.html*
- Bureau of Land Management, Red Rock Canyon National Conservation Area *www.redrockcanyon.blm.gov*
- Mojave Desert Ecosystem Program *www.mojavedata.gov*
- National Biological Survey: Status and Trends of the Nation's Biological Resources *http://biology.usgs.gov/s+t/SNT*
- Desert USA, Mojave National Preserve *www.desertusa.com/mnp/mnp_main.html*

References

Berry, K. (1997). The desert tortoise recovery plan: an ambitious effort to conserve biodiversity in the Mojave and Colorado Deserts of the United States. in *Proceedings: Conservation, Restoration and Management of Tortoises and Turtles — an International Conference*. New York: Turtle and Tortoise Society.

Bowers, J.E. (1999). *Flowers and Shrubs of the Mojave Desert*. Tucson, Ariz.: Southwest Parks and Monuments Association.

Clifford, F. (1996). Mojave Desert continues to tempt developers, investors; vast store of underground water may nourish agriculture and manufacturing, experts say. *Dallas Morning News*, December 22, 1996. p.14A.

Darlington, D. (1996). *The Mojave: Portrait of the Definitive American Desert*. New York: Henry Holt and Co.

Gossard, G., Peterson, C., and Savage, D. (1994). *Mojave Desert Discovery: an Educator's Guide*. Washington, D.C.: National Park Service/National Park Foundation. [ordering information: *www.nps.gov/moja/mojaedcu.html*]

Hannasch, C., Hardenbrook, E., Mitchell, G., and Murray, B. (1994). *Explore the Great Outdoors: an Information and Activities Guide for Teachers of Grades 1-5*. Las Vegas, Nev.: Friends of Red Rock Canyon, Environmental Education Committee.

Lovich, J. (1995). Human-induced changes in the Mojave and Colorado Desert Ecosystems: recovery and restoration potential. in *Status and Trends of the Nation's Biological Resources*. Washington, D.C.: National Biological Survey. Available online at *http://biology.usgs.gov/s+t/SNT/noframe/gb151.htm*

National Park Service. (1998). *Draft Environmental Impact Statement and General Management Plan; Mojave National Preserve, California*. Barstow, Calif.: National Park Service.

Schad, J. (1988). *California Deserts*. Helena, Mont.: Falcon Press.

About the Authors and Artist

Bibi Booth, Elizabeth Wooster, and Elizabeth Rieben are Bureau of Land Management (BLM) Environmental Education Specialists; Richard Brook is a BLM Archaeologist; Shelly Fischman is a BLM Environmental Education Specialist.

Acknowledgments

The authors would like to express their appreciation to the following people for their assistance with this article: David Miller, U.S. Geological Survey; LaVonda Walton, U.S. Fish & Wildlife Service; and our colleagues at the Bureau of Land Management: Jeff Aardahl, Kathy August, Brad Blomquist, Greg Gnesios, Bill Haigh, Gayle Marrs-Smith, Ron Montagna, Tim Rash, Judyth Reed, Tim Salt, Doran Sanchez, Sid Slone, Steve Smith, Rick Stamm, Alan Stein, and Dave Wolf.

U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT